

ECOSYSTEM STATUS INDICATORS

Physical Environment

ALEUTIAN ISLANDS

Water temperature data collections – Aleutian Islands Trawl Surveys

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A Brief Description of Water Flow in the Aleutian Islands

The oceanographic characteristics of water flowing through passes in the Aleutian Archipelago have been summarized and reported by Favorite et al. (1976), Stabeno et al. (1999) and Reed and Stabeno (1999) among others. The following two introductory paragraphs are drawn from largely complementary parts of their papers on the oceanography of the subarctic Pacific Ocean, the physical oceanography of the Bering Sea, and the Aleutian North Slope Current, respectively.

The water currents that flow around the Aleutian Islands are most heavily influenced by the Alaskan Stream, the northern edge of the North Pacific subarctic gyre that moves westward along the continental slope, south of the archipelago. Parts of the Alaskan Stream flow in an intermittent fashion through passes between the islands supplying much of the water that circulates in the Bering Sea. The strength of this flow varies on a scale of days or weeks or more. Water flow into the Bering Sea can change by a factor of two or more. Tides play an important part in mixing water masses as they encounter each other and prominent topographical features. The Alaskan Stream occasionally may be dislocated southward, possibly contributing less transport through the passes.

South to north water movement through two deep passes, Amukta Pass and Amchitka Pass, is the primary source of the Aleutian North Slope Current, a relatively narrow flow that moves northeastward along the north side of the islands and bends northward and westward to become the Bering Slope Current. Further west the Alaskan Stream flows through Buldir Pass and Near Strait near Stalemate Bank and branches eastward along the north side of the islands toward Petrel Bank. Some of this water flows south through the many passes between the islands.

The presence of Alaskan Stream water is usually typified by temperatures warmer than 4° C to depths of 200 m or more. In general, Alaskan Stream water moves northward through the eastern side of the major passes. Occasionally the westward margin curves to the west and south arcing around to rejoin the inflow or sometimes to rejoin the Alaskan Stream. The Aleutian North Slope Current commonly forms eddies, ultimately sending water southward through the shallower passes (specifically cited, Segum Pass), where it may flow westward along the southern continental shelf or rejoin the Alaskan Stream to flow west again, possibly reentering the Bering Sea at a later time.

Implications for Groundfish Reproduction and Recruitment

Although representing a relatively small volume of water, eddies that re-circulate water over or near the shelf might be important to concentrate primary production. They may also contribute to successful reproduction and recruitment of the major Aleutian semi-pelagic species such as Atka mackerel, Pacific Ocean perch, northern rockfish, and walleye pollock. For example Segum Pass is a known area of Atka mackerel spawning off Segum and Amlia Islands and at probable locations on offshore rock outcrops south of Segum Island (personal video observations of typical male nest guarding behavior). The implications of clockwise movement of water flowing past spawning grounds and then westward over the

southern shelf, or within the northern margin of the Alaskan Stream, to ultimately deposit post-larval or young-of-the-year fish in favorable feeding and protective habitat should be investigated.

Trawl Survey Temperature Profiles – What They Can Show

Stabeno et al. (1999) report on two vertical sections of temperatures across Amukta Pass between Amukta I. and Seguam I. collected in August. The 1994 data reflect a vertically mixed temperature distribution during a period of strong south to north flow through the pass. Relatively warm Alaskan Stream water ($\sim 4.5^{\circ}\text{C}$) reached almost to a depth of 400 m on the eastern (inflow) side of the pass. This is contrasted with a period of low inflow one year later during which the water column temperature distribution was much more stratified with a cold water outflow ($\sim 3.5^{\circ}\text{C}$) on the western side of the pass. These distinct situations might be detectable by viewing trawl survey temperature profiles from middle-depth and deep trawl stations.

Groundfish assessment survey periods have ranged from early May to late September, with no fixed sampling pattern or time schedule. Generally, sampling progresses from east to west, but notable exceptions exist especially for the earliest three surveys and for the 2002 survey. Surface to bottom temperature profiles have been routinely collected in conjunction with bottom trawl hauls. Of the eight survey years cited in the figure below, all except 1991 had temperature profiles from throughout the Aleutian survey area.

Wolter and Timlin (1993, 1998) produced a multivariate El Niño/Southern Oscillation (ENSO) index (MEI) that is presented graphically and regularly updated at the following website: Klaus Wolter (kew@cdc.noaa.gov). Comments on the timing of ENSO events cited herein reference that graph. The year 2000 produced the coldest bottom temperatures yet detected during summer AFSC groundfish surveys (Figure 32). The warmest years tend to be associated with El Niño events. The three coldest years thus far detected (1994, 2000, and 2002) have occurred within the last eight years, with one of the warmest (1997) occurring in their midst (Figure 32). Those colder years were associated with La Niña events (2000 and 2002) or a strongly decreasing El Niño event (1994). The warm 1997 temperatures were associated with a very strong El Niño event. Generally mean temperatures at depth intervals shallower than 300m vary more than those deeper than 300m. Perhaps the year 2000 temperatures are not as anomalous as they appear, but many individual fish weighed and measured during the survey were notably lighter than during other surveys. Unfortunately, we have no data to compare for the intervening years. The 2004 data fall in the middle of the year-specific bottom temperatures and correspond to a moderate, increasing MEI.

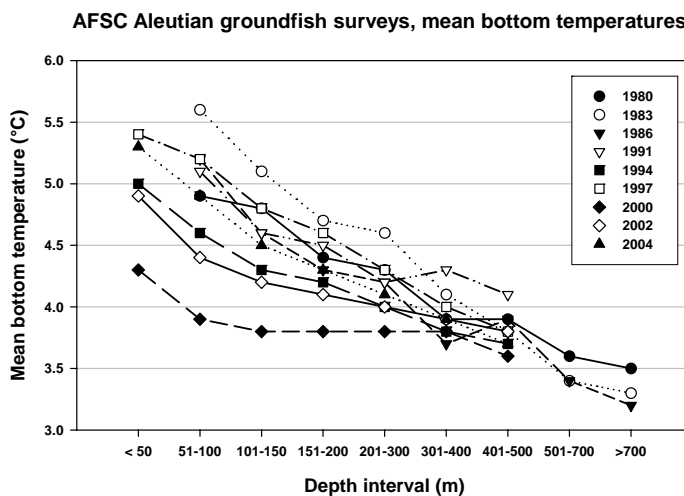


Figure 32. Mean bottom temperatures from the Alaska Fisheries Science Center (AFSC) groundfish surveys (1980-2004).

ENSO events are monitored using the Multivariate ENSO Index (MEI) which is based on six observed variables over the tropical Pacific: sea-level pressure, zonal and meridional components of the surface wind, sea surface temperature, surface air temperature, and total cloudiness fraction of the sky. Given the apparent correlation between the within-year MEI trends and summer mean bottom temperatures in the Aleutian archipelago, further investigation seems promising. If a correlation exists between the MEI and oceanographic events controlling Aleutian survey bottom temperatures, it might be demonstrated graphically as a linear relationship between mean MEI for the period from slightly before the start to the end of the groundfish survey period. Low MEI should correspond to low bottom temperatures and high mean MEI should correspond to higher bottom temperatures. Mean MEIs for the period from March to the end of each survey period were plotted against mean bottom temperature for four depth intervals (Figure 33). March was used as a starting point because most of the ENSO events began in spring or early summer (Hollowed et al. 2001). Correlation coefficients are included for each trend line and range from 0.67 and 0.81 suggesting that mean MEI and bottom temperatures to a depth of 300 m are somehow related (Figure 33). The weakest correlation is in the shallowest depth interval, where one might expect to find the most influence of seasonally warmed surface water and storm-caused mixing. Such short term, within-year effects are likely the result of atmospheric forcing and the position and strength of the Aleutian low-pressure phenomenon (Hollowed et al. 2001).

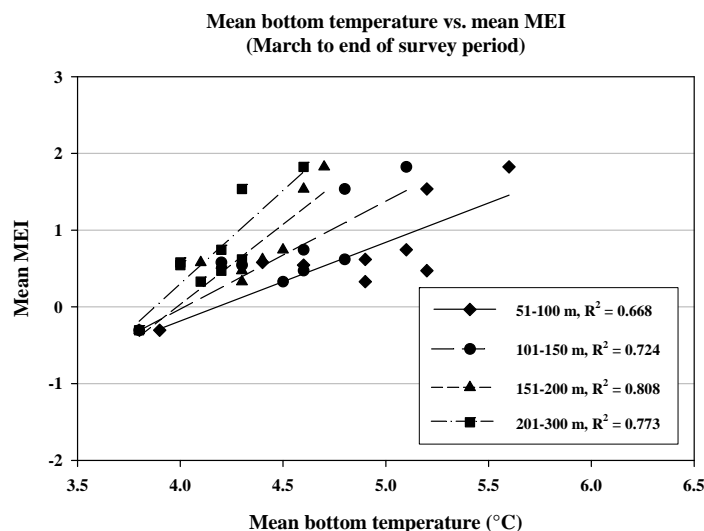


Figure 33. Multivariate ENSO Index (MEI) as a function of mean summer bottom temperatures in the Aleutian archipelago.

Water Temperatures Across the Survey Area

Figure 34 summarizes station-specific bottom temperature distributions by longitude for the 1994, 1997, 2000, 2002, and 2004 Aleutian Islands bottom trawl surveys. Several features appear to reoccur and warrant further comment along with some exceptions. Relatively warm bottom temperatures appear between 173°E and 176°E longitudes probably resulting from Alaskan Stream water washing over Tahoma Bank and Walls Plateau. Relatively cold temperatures found between 172°W and 174°W longitudes were probably the result of Bering Sea water flowing along the northern slope and onto the lower shelf. While the mean temperatures for 1997 were warmer than all survey years except 1983, the spread of temperatures was generally broader than other post-1991 surveys. The warm temperatures noted near the western end of the survey area were not as evident during the 2002 survey. This may have resulted from earlier than usual sampling in that area. The warm temperatures detected between about

170°W and 172°W longitudes in 2002 were probably caused by seasonal warming and may have resulted from much later than usual sampling in that area.

Figure 35 shows 2004 survey water temperatures at 12 depths from near surface to near bottom, by longitude. There were areas of warm near-surface water between approximately 170°E to 176°E and 175°W to 177°W longitudes. Generally, 2004 summer water column temperatures shallower than 200 m were somewhat warmer than in 2002. Below 200 m, temperatures were similar in both years.

Judging by past survey results, the elevated late summer, near-surface temperatures at the western end of the survey area appear to be more the rule than the exception. In 2002 sampling occurred earlier than usual and that might have contributed to the low temperatures in 25 m or shallower noted in last year's edition of this summary.

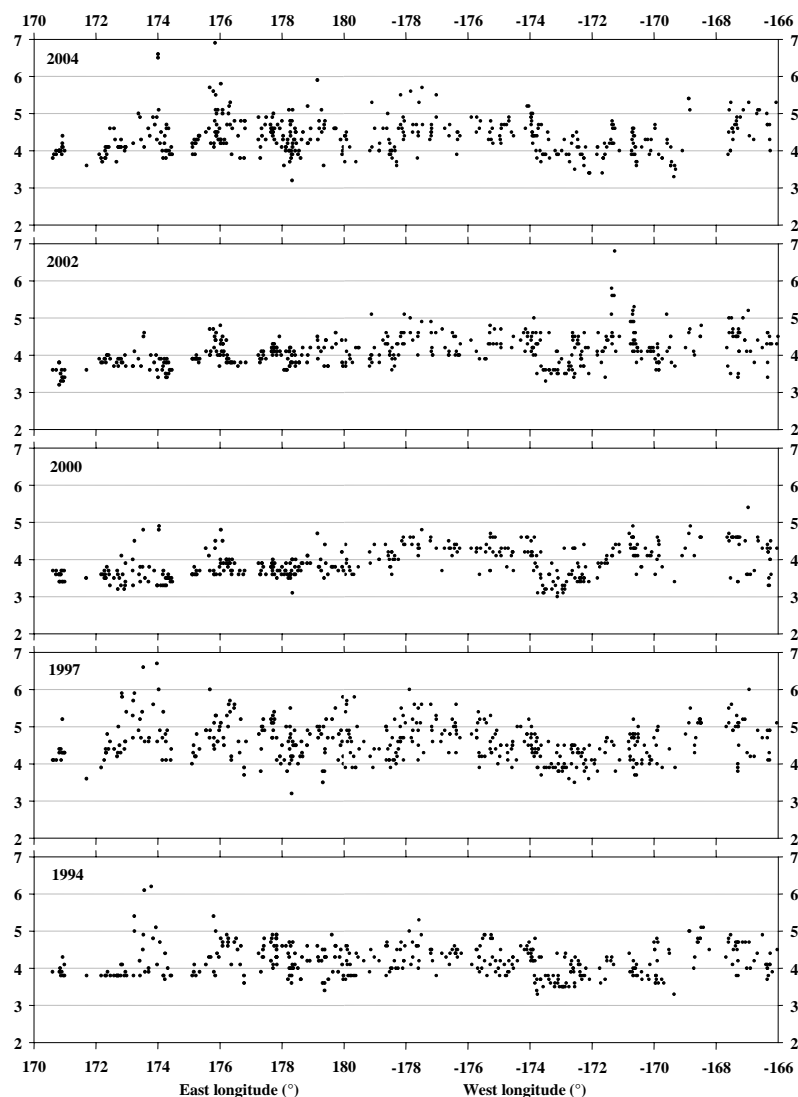


Figure 34. Bottom temperatures collected during the five most recent AFSC Aleutian Islands bottom trawl surveys, by longitude

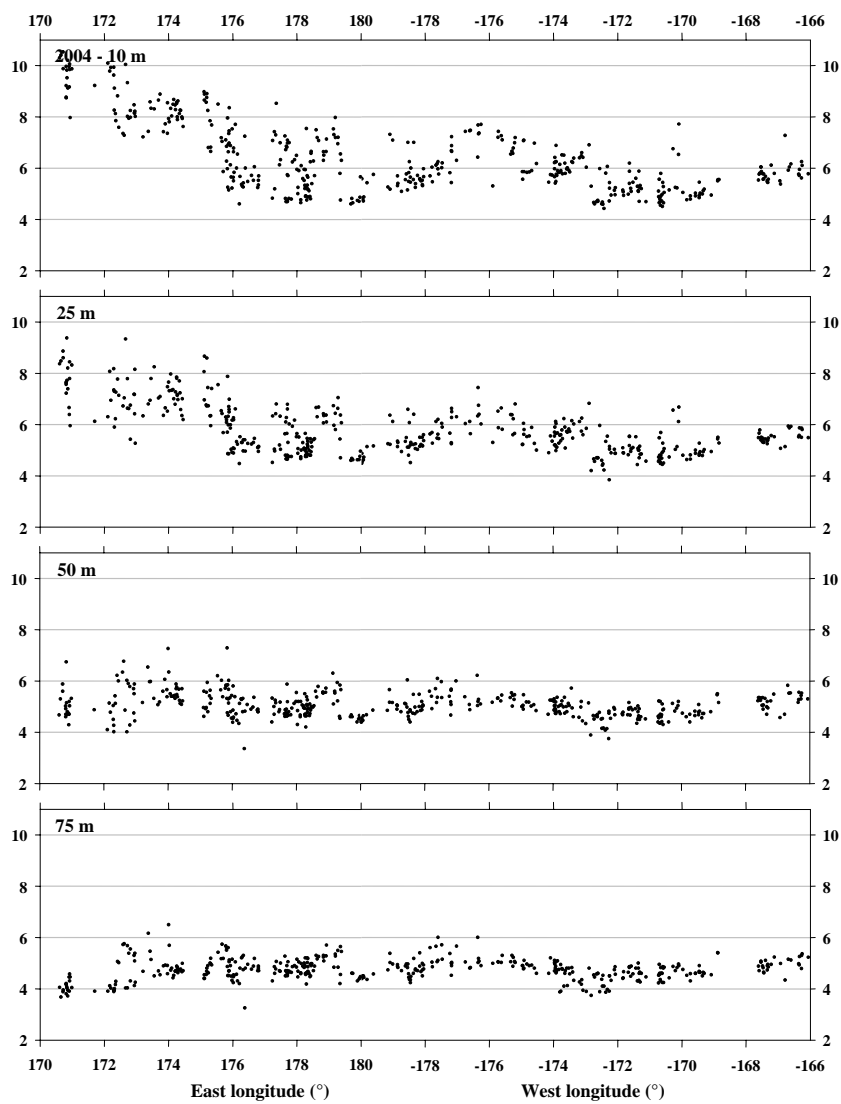


Figure 35. Temperatures at 12 depths by longitude, collected during the 2004 AFSC Aleutian Islands bottom trawl survey.

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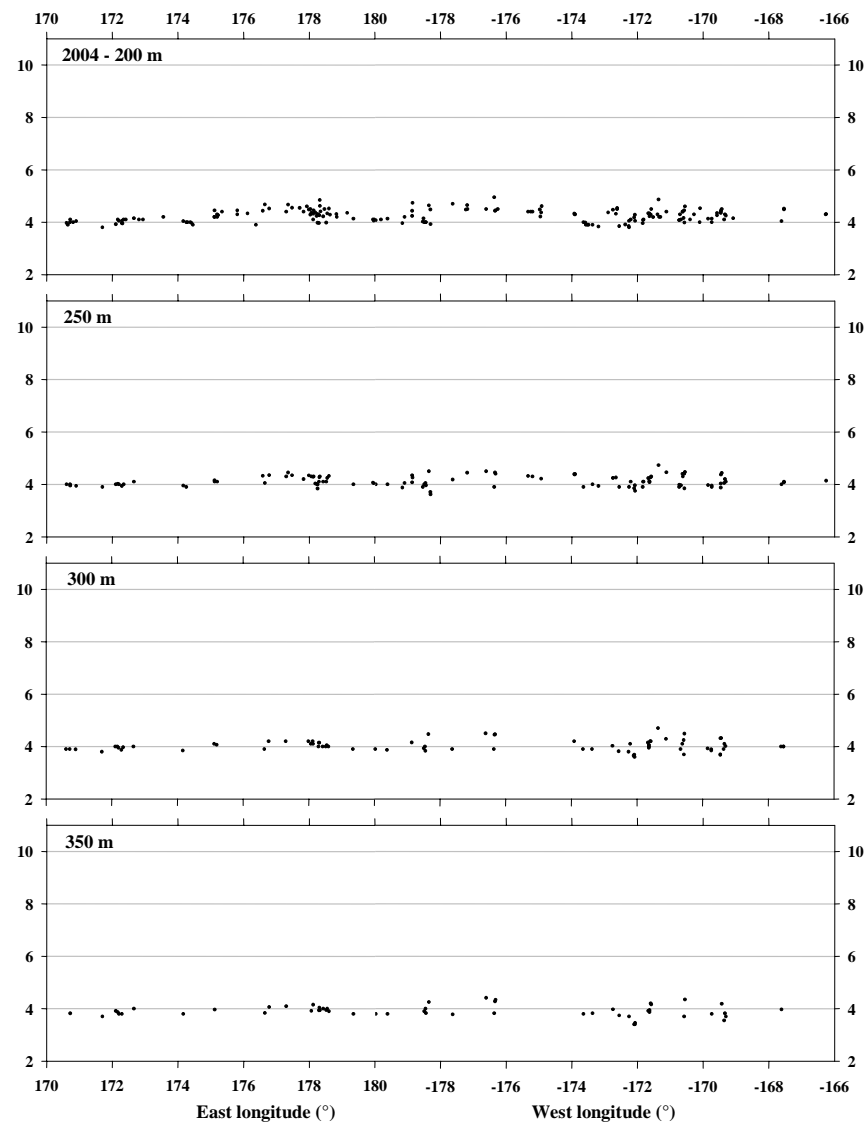
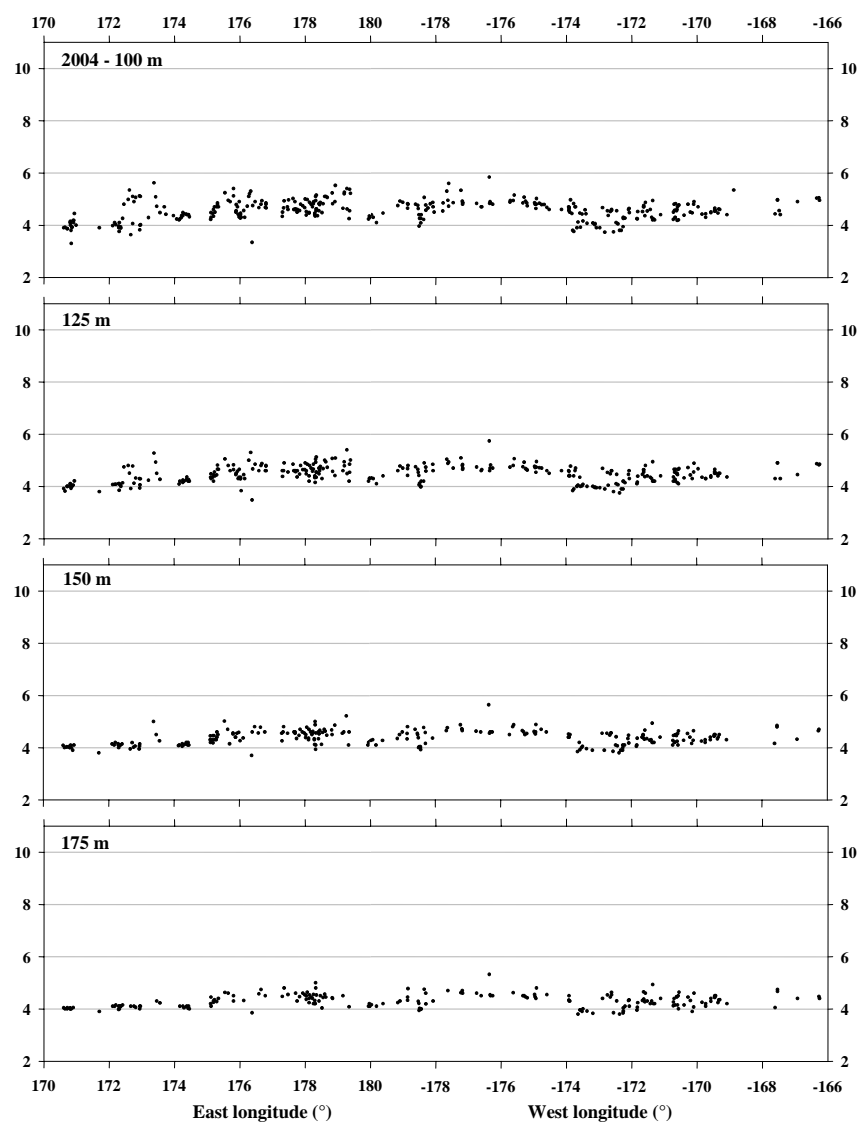


Figure 36 continued. Temperatures at 12 depths by longitude, collected during the 2004 AFSC Aleutian Islands bottom trawl survey.

